Economic Sciences
https://economic-sciences.com
ES (2025) 21(1S), 79-87| ISSN:1505-4683

Modelling India's LNG Import Demand up to 2047 and Evaluating Terminal Capacity Adequacy

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Abstract

This study forecasts India's LNG import demand up to 2047 and evaluates the adequacy of regasification terminal capacity under various utilisation scenarios. An ARIMA(1,1,0) model was applied to historical LNG import data from 2014 to 2023 to generate conservative upper-bound forecasts. The results indicate a gradual upward trend in LNG imports, with estimates suggesting a significant growth in import volumes by the mid-2040s. These forecasts were translated into the required terminal capacity by applying three utilisation scenarios (60 %, 70 %, and 80 %) to account for operational downtimes and maintenance requirements. Under the 60% utilisation scenario, capacity demand increases markedly compared with higher utilisation levels, highlighting potential infrastructure gaps relative to current and planned capacities. The findings underscore the importance of adopting a conservative scenario-based planning framework to ensure energy security and inform investment decisions in LNG infrastructure. Future studies should incorporate additional variables, such as industrial consumption and policy dynamics, to refine these long-term forecasts and support more resilient infrastructure planning.

Keywords: *LNG imports, ARIMA forecasting, capacity demand, scenario analysis, regasification terminal.*

Introduction

India's rapidly growing energy needs and its strategic pivot toward greener energy sources are poised to significantly boost the nation's LNG demand in the coming decades. Rising consumption necessitates careful terminal capacity planning and dependable supply chain management to accommodate this trend. Ghosh et al. (2024) project that by 2050, 30–50% of India's natural gas requirements will be met through imports, predominantly as LNG. This anticipated growth mirrors broader patterns in the Asia-Pacific, where LNG imports are expected to rise by 95.7% from 2013 levels by 2030, with India playing a major role in this increase (Kompas & Che, 2016).

To support this surge, India must urgently expand its terminal infrastructure. Enhancing terminal capacity is essential to maintain a consistent LNG supply and avoid potential bottlenecks. Infrastructure development, particularly in regasification facilities, is pivotal to sustaining the expansion of the LNG market in Asia, including India (Egging et al., 2010). Moreover, diversifying the supplier base is crucial, as models highlight the importance of a secure and varied LNG trading portfolio (Magnier & Jrad, 2019).

While LNG imports present considerable opportunities, several challenges remain. Establishing policy frameworks that stimulate infrastructure development and market diversification is necessary, especially in light of ongoing geopolitical risks and volatile oil prices (Kompas & Che, 2016). Simultaneously, maintaining investments in renewable energy is vital to achieving long-term sustainability goals, even though LNG offers a cleaner alternative to coal (Ghosh et al., 2024). To uphold environmental commitments and strengthen energy security, India must both diversify supply sources and expand terminal capacities in step with escalating LNG demand.

India's approach to energy security has thus increasingly centered around boosting natural gas and LNG imports. Over the past decade, the country has nearly doubled its natural gas consumption, reshaping its position in the global market (Vivoda, 2014). As a result, India now ranks among Asia's top five LNG importers, alongside China, Japan, South Korea, and Taiwan (Vivoda, 2019). Addressing the widening domestic supply-demand gap necessitates a significant increase in LNG imports. In 2017, Asian countries collectively accounted for 72% of global LNG imports, and this dominance is expected to continue. With annual imports nearing 23 MMTPA and set to grow (Dhameliya & Agrawal, 2016), building a diversified supply portfolio becomes crucial to minimizing costs and mitigating risks associated with economic volatility.

Beyond fulfilling energy requirements, LNG imports offer important environmental advantages. Proper utilization of the cold energy produced during LNG regasification could, for example, reduce reliance on coal and support cleaner power generation (Dhameliya & Agrawal, 2016). Nevertheless, environmental benefits can vary depending on the LNG's source, as lifecycle emissions differ across regions, introducing an additional layer of climate-related uncertainty.

The global LNG market has experienced profound changes over the past two decades. Between 2000 and 2017, Asia's natural gas consumption more than doubled, raising the region's share of global demand from 13% to 21% (Vivoda, 2014, 2019). This expansion has fueled heightened competition among exporters and encouraged the shift toward spot markets and short-term contracts (Chen et al., 2016; Maxwell & Zhu, 2011; Chen et al., 2016; Maxwell & Zhu, 2010). Additionally, new shipping routes such as the Northern Sea Route and the widened Panama Canal have further influenced LNG trade flows (Shibasaki et al., 2018).

Given this dynamic global backdrop, LNG imports have become a cornerstone of India's broader energy strategy. Ambitious targets, including raising the share of natural gas to 15% of the overall energy mix by 2030 (MOPNG, 2022), demand a critical evaluation of whether existing and upcoming regasification terminals can meet the expected growth in LNG volumes. The Government of India, through multiple recent statements and initiatives, has underlined the importance of expanding infrastructure to safeguard energy security (PIB, 2024b). Furthermore, sustained policy actions reflect a strong commitment to energy independence and sustainability (PIB, 2024a). Reliable LNG demand forecasting remains crucial for ensuring prudent long-term energy planning, enabling investments that avoid the pitfalls of both stranded assets from overcapacity and supply shortages from insufficient infrastructure (IEA, 2024; IGU, 2024).

Study Purpose and Significance

This research aims to project India's LNG import demand up to 2047 by developing a robust, GDP-driven forecasting model. As India continues its rapid economic expansion and shifts towards cleaner energy sources, ensuring that LNG import infrastructure aligns with future demand is critical for securing energy supplies. Accurate forecasts enable policymakers and industry stakeholders to plan infrastructure investments judiciously, mitigating the risk of both supply shortages and excessive capacity that leads to stranded assets (MOPNG, 2022). Given the recent policy announcements and infrastructure initiatives from the Government of India (PIB, 2024a, 2024b), evaluating the adequacy of current and planned regasification terminals becomes increasingly significant for long-term energy security and sustainable economic growth.

The primary objectives of this study are twofold: first, to develop a model to forecast annual LNG imports in India from 2024 to 2047, and second, to compare these forecasted demand figures with existing and planned regasification terminal capacities to identify potential infrastructure gaps. In addressing these objectives, the study seeks to answer two critical questions: How does India's GDP growth influence LNG import volumes, and what realistic demand scenarios can be projected up to 2047? Furthermore, is the current and planned regasification infrastructure adequate to meet these projected LNG demand scenarios?

The evolving global LNG trade landscape and India's strategic energy imperatives necessitate a detailed examination of future LNG import demand. By integrating LNG cargo import data into a forecasting model, this study seeks to provide critical insights into whether India's regasification capacity is poised to accommodate rising demand over the coming decades. Such an analysis will support evidence-based policy formulation and investment planning, ensuring the country's energy infrastructure development is responsive and resilient in dynamic global market conditions.

Methods

This study employs a time-series forecasting approach using the ARIMA model to predict India's LNG import demand from 2024 to 2047. Given the limited dataset—10 annual observations from 2014 to 2023—an ARIMA model was chosen for its robustness in modelling temporal dependencies (Hyndman, 2018). All analyses were conducted in Google Colab using Python libraries such as pandas, statsmodels, and pmdarima.

Data Preparation and Model Specification

Historical LNG import data (in MMT) for 2014–2023 were collected and indexed by year, with the financial year assumed to correspond to the starting calendar year. The dataset was visualised to inspect trends and potential anomalies. While multiple regression techniques have been used in energy forecasting (Dhameliya & Agrawal, 2016), this study excludes exogenous variables (such as GDP growth) due to data constraints and focuses solely on historical LNG imports.

An ARIMA model was estimated using the auto_arima function from the pmdarima package to determine the optimal (p,d,q) parameters based on information criteria (AIC/BIC). After comparison, an ARIMA(1,1,0) specification was selected for forecasting.

Forecasting with Upper Bound Confidence Interval

To account for uncertainty and adopt a conservative planning approach, forecasts for 2024–2047 were generated using the upper bound of the ARIMA model's confidence intervals. This upper-bound forecast represents a "worst-case" demand scenario. The forecasting process involved:

- Generating forecasts for 24 future periods using the fitted ARIMA model.
- Extracting the upper confidence interval for each forecasted value.
- Creating a DataFrame with a date range from 2024 to 2047 to label the forecasts.

This approach is supported by previous studies recommending conservative estimates for critical infrastructure planning (IEA, 2024).

Capacity Demand Estimation under Utilization Scenarios

Given that regasification terminals rarely operate at 100% capacity due to maintenance and operational constraints, three utilisation scenarios were considered: 60%, 70%, and 80%. Required terminal capacity was computed by dividing the upper-bound LNG import forecast by the respective utilisation factor. For example, if the forecasted LNG import for a year is X MMT, the required capacity at 60% utilisation is calculated as X/0.60. The decision-makers should focus on the upper bound of the forecast confidence interval to adopt a conservative perspective for infrastructure planning. Table 1 presents the resulting upper bound forecasts by year (2024–2047). Notably, the forecast for 2024 began at approximately 28.82 MMT, increasing to over 50 MMT by the mid-2040s. While these numbers represent a "worst-case" scenario, they provide valuable insights for ensuring sufficient terminal capacity to accommodate potential demand spikes.

Software and Implementation

All analyses were performed using Python on Google Colab.

Results

Figure 1 illustrates India's historical LNG imports from 2014 to 2023. As shown, imports rose steadily from approximately 14 MMT in 2014 to a peak of approximately 25–26 MMT by 2019–2020. A moderate decline was observed in 2021–2022, followed by a partial recovery in 2023. These fluctuations underscore the importance of developing a robust forecasting approach that accounts for short-term volatility and long-term growth trends.

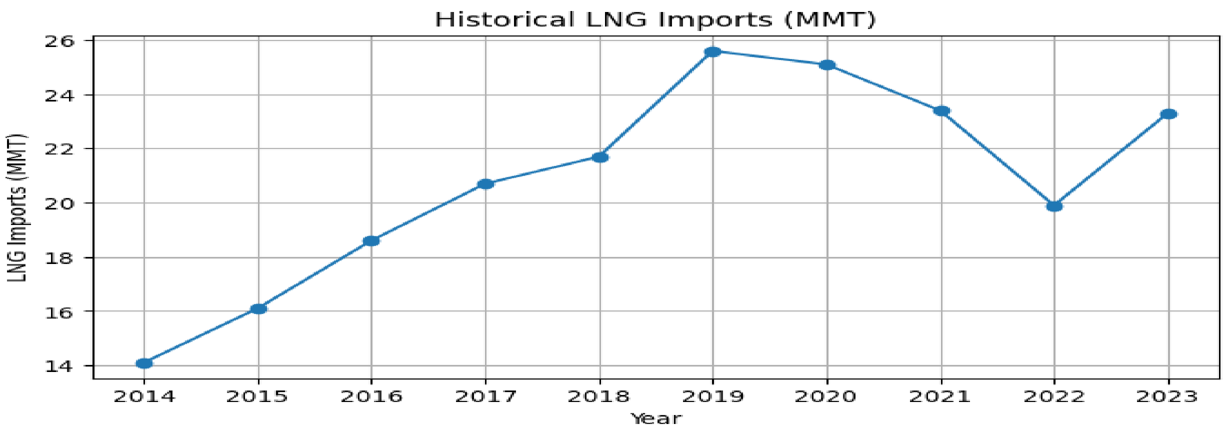

Figure 1: Historical LNG Imports

ARIMA Forecast (Upper Bound)

The ARIMA(1,1,0) model was employed to forecast LNG imports from 2024 to 2047. To adopt a conservative perspective for infrastructure planning, the analysis focused on the **upper bound** of the forecast confidence interval. Table 1 presents the resulting upper bound forecasts by year (2024–2047). Notably, the forecast for 2024 began at approximately 28.82 MMT, increasing to over 50 MMT by the mid-2040s. While these numbers represent a "worst-case" scenario, they provide valuable insights for ensuring sufficient terminal capacity to accommodate potential demand spikes.

Table 1: Upper-Bound LNG Import Forecasts, 2024–2047)

Year	LNG (MMT)	Year	LNG (MMT)
2024	28.82	2036	45.43
2025	31.64	2037	46.26
2026	33.74	2038	47.07
2027	35.46	2039	47.84
2028	36.96	2040	48.59
2029	38.30	2041	49.32
2030	39.52	2042	50.03
2031	40.65	2043	50.72
2032	41.71	2044	51.39
2033	42.71	2045	52.05
2034	43.66	2046	52.69
2035	44.56	2047	53.31

These forecasts highlight a general upward trend in LNG imports, reflecting India's expanding energy requirements and the global push toward cleaner fuel alternatives (Hyndman, 2018). However, the widening confidence intervals over the 24-year horizon underscore the uncertainty of long-range forecasting, particularly given a limited historical dataset.

Capacity Demand Under Utilization Scenarios

Three terminal utilisation scenarios (60 %, 70 %, and 80 %) were examined to translate the upper-bound

LNG forecasts into practical infrastructure requirements. Table 2 shows how each year's upper-bound import projection converts into the required regasification capacity under these different utilisation rates. For instance, in 2024, an upper-bound import forecast of approximately 28.82 MMT translates to a capacity demand of about 48.04 MMT under 60% utilisation, 41.18 MMT under 70% utilisation, and 36.03 MMT under 80% utilisation.

Table 2: Capacity Demand at 60%, 70%, and 80% Utilization

Year	LNG Import Forecast (MMT)	Capacity at 60% Utilisation (MMTPA)	Capacity at 70% Utilisation (MMTPA)	Capacity at 80% Utilisation (MMTPA)
2024	28.82	48.04	41.18	36.03
2025	31.65	52.75	45.21	39.56
2026	33.75	56.24	48.21	42.18
2027	35.47	59.11	50.67	44.34
2028	36.96	61.60	52.80	46.20
2029	38.30	63.84	54.72	47.88
2030	39.52	65.87	56.46	49.40
2031	40.66	67.76	58.08	50.82
2032	41.72	69.53	59.59	52.15
2033	42.72	71.19	61.02	53.40
2034	43.66	72.77	62.38	54.58
2035	44.57	74.28	63.67	55.71
2036	45.44	75.73	64.91	56.80
2037	46.27	77.11	66.10	57.84
2038	47.07	78.45	67.25	58.84
2039	47.85	79.74	68.35	59.81
2040	48.60	81.00	69.43	60.75
2041	49.33	82.21	70.47	61.66
2042	50.03	83.39	71.48	62.54
2043	50.72	84.54	72.46	63.40
2044	51.40	85.66	73.42	64.24
2045	52.05	86.75	74.36	65.06
2046	52.69	87.82	75.27	65.87
2047	53.32	88.87	76.17	66.65

Table 2 indicates that lower utilisation assumptions lead to higher capacity requirements, while higher utilisation scenarios (e.g., 80%) reduce the total capacity needed. By 2027–2028, capacity demands will exceed 50 MMT under the 60% scenario, emphasising the importance of strategic planning to prevent supply bottlenecks. Conversely, India could manage with a lower total capacity if terminals can be run more efficiently—closer to 80% utilisation. The choice of utilisation factor thus directly affects capital investment decisions for new or expanded terminals.

Interpretation and Policy Implications

Balancing Supply Security and Overcapacity

Relying on the upper bound of the ARIMA forecast ensures a margin of safety, reducing the risk of underestimating future LNG demand. However, it may also result in overbuilding if actual imports align more closely with the mean forecast rather than the upper limit. Striking the right balance between mitigating supply shortages and avoiding idle infrastructure is a key challenge for policymakers and industry stakeholders (IEA, 2024).

Addressing Infrastructure Gaps

Comparing the forecasts in Table 1 and the capacity demands in Table 2 with current and planned regasification infrastructure can reveal potential shortfalls. Significant expansion or additional facilities may be required if the cumulative capacity of existing terminals—such as Dahej, Kochi, Hazira, Dabhol, Ennore, Mundra, and Dhamra—does not keep pace with these conservative demand estimates. This expansion could involve new terminals, technology upgrades, or partnerships with global LNG suppliers to secure reliable, diversified supply routes.

Scenario-Based Planning

The three utilisation scenarios offer a flexible framework for decision-making. For example, capacity requirements are notably higher under a 60% utilisation assumption, which may prompt more aggressive investment in terminal construction. In contrast, a scenario that assumes 80% utilisation might prioritise operational efficiency and advanced technologies to handle larger volumes with less idle capacity. Such scenario-based planning allows adaptive strategies to be recalibrated as new data emerge or global LNG markets evolve.

Limitations and Future Work

Although the ARIMA(1,1,0) model provides a structured approach for forecasting, it is constrained by the relatively small dataset (10 annual observations) and the inherent uncertainty of projecting nearly two decades into the future. Additional variables—such as domestic policy changes, global LNG price fluctuations, or industrial consumption patterns—could be integrated to refine these forecasts further. Expanding the historical data range, including more recent observations, or employing alternative forecasting methods (e.g., vector autoregression or dynamic regression with exogenous variables) may also improve model accuracy (MOPNG, 2022).

Historical data indicate that LNG imports in India have experienced significant growth over the past decade, rising from around 14 MMT in 2014 to over 25 MMT by 2019–2020, followed by a temporary dip and subsequent partial recovery. ARIMA projections based on this historical trend suggest that, under a worst-case scenario, imports could reach the upper 20s (in MMT) by 2024 and exceed 50 MMT by the mid-2040s. These projections reflect a conservative approach that uses the upper-bound confidence intervals to ensure that potential peaks in demand are adequately considered in infrastructure planning.

When translating these import forecasts into capacity requirements, the analysis shows that under a 60% utilisation scenario, the required regasification capacity is substantially higher than scenarios assuming 70% or 80% utilisation. By the late 2020s, capacity demands under the 60% scenario are projected to surpass 50 MMT, highlighting potential gaps in the existing and planned terminal infrastructure. Balancing the risk of supply shortages against the cost of overcapacity is crucial; hence, scenario-based planning enables a more flexible and adaptive approach to future expansions. These findings underscore the value of a conservative, scenario-based methodology for long-term LNG infrastructure planning. While the upper-bound forecasts and utilisation scenarios help policymakers avoid underestimating demand, further research incorporating a broader dataset and additional explanatory factors is essential to refine these estimates and support more nuanced energy policy decisions.

Discussion

This study set out to forecast India's liquefied natural gas (LNG) imports up to 2047 using an ARIMA(1,1,0) model and then translate those projections into terminal capacity requirements under three different utilisation scenarios. The conservative choice of focusing on the upper bound of the forecasted LNG imports reflects a strategic approach to mitigating potential supply shortfalls—particularly relevant given India's increasing reliance on LNG as part of its broader energy transition efforts (IEA, 2024).

Forecast Accuracy and Data Constraints

A fundamental issue in forecasting is data availability and quality. In this research, only 10 annual observations (2014–2023) were available for model training. While ARIMA models can yield reasonable short-term projections even with limited data (Hyndman, 2018), the 20-plus-year horizon to 2047 introduces substantial uncertainty. The widening confidence intervals in the forecast results highlight this uncertainty, indicating that unforeseen events—such as policy shifts, technological breakthroughs, or major global market disruptions—could significantly alter actual LNG demand. Future research could benefit from extending the historical dataset and incorporating more frequent observations (e.g., quarterly data) to enhance model robustness and granularity.

Justification for Upper-Bound Forecasting

By choosing the upper confidence interval as the forecasted LNG import volume, this study adopts a conservative stance that aims to ensure supply security. While this approach may lead to overestimation if actual demand remains closer to the mean or lower-bound estimates, the potential downside of underestimating demand—leading to infrastructure bottlenecks and energy shortages—can carry higher economic and social costs. This conservative planning mindset is often employed in critical infrastructure projects where the risks of undersupply outweigh the potential inefficiencies of occasional overcapacity (MOPNG, 2022).

Scenario-Based Capacity Planning

One of the study's notable contributions is the scenario-based analysis of terminal utilisation rates. The research highlights how operational efficiency significantly impacts capacity requirements by examining 60%, 70%, and 80% utilisation. Under a 60% utilisation assumption, required capacity expands rapidly, implying more significant investments in regasification infrastructure. Conversely, an 80% utilisation assumption produces comparatively lower capacity needs, suggesting a more optimised use of existing infrastructure. However, higher utilisation may require advanced technologies, well-coordinated maintenance schedules, and potentially robust demand management strategies. This trade-off underscores the complexity of planning large-scale energy infrastructure.

Policy and Investment Implications

India's current LNG regasification infrastructure—spread across terminals like Dahej, Kochi, Hazira, Dabhol, Ennore, Mundra, and Dhamra—has a finite capacity, some of which is already nearing high utilisation levels (PIB, 2024a). The forecasted increases in LNG demand, particularly under conservative (upper-bound) scenarios, suggest that significant capacity expansion could be necessary to avoid supply disruptions. Policymakers and investors must balance the capital costs of constructing or upgrading terminals against the strategic imperative of ensuring energy security. Moreover, integrating these capacity expansion plans with pipeline networks and city gas distribution systems is crucial for maximising the economic benefits of LNG imports.

Furthermore, domestic natural gas production, pipeline imports, and alternative fuels (e.g., hydrogen or biogas) could alter the future role of LNG. If India's domestic gas production expands significantly or alternative fuels gain market share, the projected LNG demand might be lower than expected. Conversely, if domestic production stagnates or alternative fuels fail to scale quickly, LNG imports could surpass even the upper-bound forecasts. Policymakers thus need to maintain flexibility, periodically revisiting demand projections and adjusting infrastructure strategies accordingly.

Environmental Considerations

While LNG is often touted as a cleaner alternative to coal and oil, it is not entirely without environmental impact. Methane leaks along the supply chain, lifecycle emissions from liquefaction to regasification, and energy consumption during transport contribute to the overall carbon footprint. Although the present study focuses primarily on the infrastructure needed to handle future LNG demand, a comprehensive assessment would also consider the environmental trade-offs of large-scale LNG adoption. Policymakers promoting LNG as a bridge fuel must weigh its relative cleanliness against potential emissions, especially if the country's climate commitments become more stringent.

Limitations and Future Directions

In addition to the small sample size and excluding exogenous variables, several other limitations warrant discussion. First, the ARIMA model does not account for seasonality or structural breaks, which could occur if major policy reforms or technological shifts occur. Second, while the scenario-based capacity analysis provides a valuable framework, it simplifies operational realities. Terminals rarely operate at a fixed utilisation rate over an entire year; peak demands, maintenance outages, and fluctuations in global LNG prices can all influence actual throughput. Third, this research does not quantify the economic or environmental costs of building excess capacity. An integrated cost-benefit or multi-criteria decision analysis could offer further insights into the optimal level of capacity expansion.

Future work could incorporate additional data sources, such as industrial production indices, global LNG price trends, or domestic energy policies, to enhance forecast accuracy. Extending the analysis to monthly or quarterly data might reveal short-term demand patterns obscured by annual averages. Finally, advanced forecasting methods (e.g., vector autoregression, machine learning approaches) could better capture complex interactions among multiple variables that drive LNG demand.

The results affirm that India's LNG imports will likely continue upward, potentially surpassing existing and planned regasification capacities if conservative forecasts materialise. The study's capacity demand estimates under different utilisation scenarios highlight the importance of aligning operational strategies with infrastructure investments. In this way, the research provides a foundation for policymakers, investors, and energy planners to make informed decisions regarding LNG infrastructure development. Nonetheless, ongoing data collection, scenario refinement, and model enhancements are vital for adapting to the evolving energy landscape.

Conclusion

India's growing reliance on LNG necessitates proactive and adaptive infrastructure planning to ensure energy security and operational efficiency. This study employed an ARIMA(1,1,0) model to forecast LNG import volumes up to 2047, focusing on the upper bound of confidence intervals to capture a conservative demand scenario. The resulting forecasts, when combined with three utilisation scenarios (60%, 70%, and 80%), illustrate the direct impact of operational assumptions on required regasification capacity. Under the most conservative (60%) scenario, the capacity needs rise steeply, implying significant investments in new or expanded terminals.

These findings underscore two critical insights. First, forecasting is inherently uncertain, particularly over multi-decade horizons with limited historical data. While the upper-bound approach guards against underestimating demand, it may also lead to overcapacity if actual imports track closer to the mean. Second, effective policy-making and investment strategies hinge on flexible, scenario-based planning. By adjusting for different utilisation rates, stakeholders can assess possible outcomes and devise contingency plans accordingly.

ARIMA model and conservative scenario framework provide valuable inputs for capacity planning; the

Economic Sciences
https://economic-sciences.com
ES (2025) 21(1S), 79-87| ISSN:1505-4683

dynamic nature of global LNG markets, domestic policy environments, and emerging technologies necessitate ongoing reassessment. Future studies could integrate additional data sources—such as energy price dynamics, industrial consumption patterns, and evolving regulatory frameworks—to refine long-term forecasts and capacity estimates. As India expands its LNG footprint, adopting a systematic, data-driven approach to infrastructure development will be essential for balancing economic growth, energy security, and environmental considerations.

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